MICRO-ION TRAPS FOR DETECTION OF (PRE)-BIOTIC ORGANIC COMPOUNDS ON COMETS.

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Introduction: Comets are currently believed to be a mixture of interstellar and nebular material [1-3]. Many of the volatiles in comets are attributed to interstellar chemistry, because the same species of carbonaceous compounds are also observed in ices in interstellar molecular (ISM) clouds [4]. Comets are thus likely to be a relatively pristine reservoir of primitive material and carbonaceous compounds in our solar system. They could be a major contributor to the delivery of prebiotic organic compounds, from which life emerged through impacts on early Earth [5, 6].

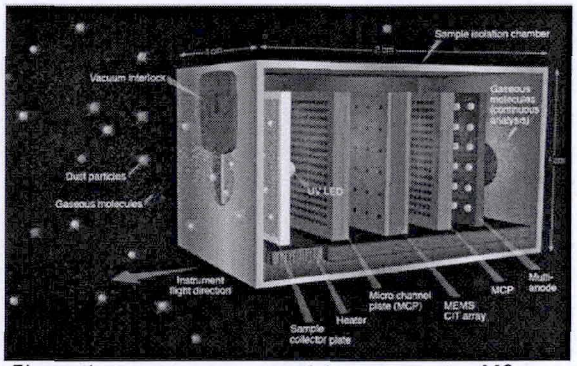

Figure 1: Artist impression of the proposed μ-MS cometary sampling concept. The total device will weigh 1000 g; its size will be 10x10x10 cm with a sample isolation chamber of 1x1x2 cm, and it will have a low power consumption of 4.5 W.

Mass spectrometers are very powerful tools to identify unknown chemicals, and much progress has been made in miniaturizing mass spectrometers for space applications [7-10]. Most miniaturized mass spectrometers developed to date, however, are still relatively large, power hungry, complicated to assemble [11, 12], and would have significant impact on space flight vehicle total payload and resource allocations.

Approach: Through previous funding, SRI has demonstrated proof-of-concept for creating high-precision arrays of extremely small (ca. 350 μm r_0) μ-cylindrical ion trap geometries (μ-CITs) in silicon, and silicon-on-insulator substrates using microelectromechanical (MEMS) fabrication techniques (Figure 2) [13, 14]. This work enables very significant miniaturization of mass spectrometers, and consequently, SRI is starting a project aimed at development of a μ-MS optimized for detection of low molecular weight prebiotic compounds in cometary environments. Such a μ-MS would be useful for guiding sample return missions to these targets by helping to identify optimal locations to collect samples, and by monitoring volatile compounds released from the samples immediately after collection and during transit back to Earth.

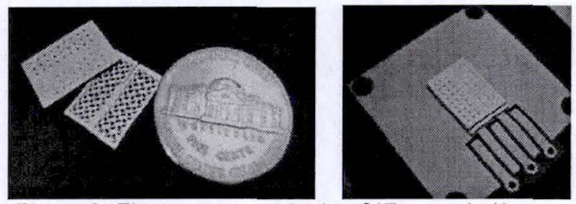

Figure 2: The two symmetrical μ-CIT array half-structures before bonding (left); the complete μ-CIT array obtained after bonding the two half-structures and mounting them on an Au-coated PCB substrate (right).

SRI has demonstrated that unit mass resolution can be obtained from μ-CITs over a small mass range while maintaining high sensitivities using an array (Figure 3).

Figure 3: Experimental mass spectral data from a single trap ($z_0/r_0 = 0.97$) in the μ-CIT array. Axial modulation was used to obtain better-than-unit mass resolution. Krypton doubly charged ions correspond to masses 82, 83, 84, and 86.

Conclusions: New missions to comets and solar system bodies, such as Enceladus, could resolve the ambiguity in the measurements by resampling for amino acids and other prebiotic chemicals. Using a μ-CIT MS diversifies opportunities for chemical analysis because

of its low mass, volume, and power. These benefits could make a μ-MS ideal for reduced-cost and descoped missions, and may open the door to including MS measurements where they were previously excluded because of power, mass, and volume constraints.

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